Software Engineering Institute

Working Summary of the SEI's Engagement with the Joint Fire Science Program

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OF THE ATTACHED DOCUMENTS, ONLY THOSE PREVIOUSLY DELIVERED TO JFSP ARE PUBLICALLY RELEASABLE; ALL OTHERS REMAIN SEI INTERNAL WORKING DOCUMENTS.

THIS REPORT IS ONLY BASED ON A PORTION OF THE SEI'S INTENDED ENGAGEMENT WITH JFSP; HAD THE ENTIRE ENGAGEMENT BEEN COMPLETED, SOME OR ALL OF THE REPORT MAY HAVE CHANGED.

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Forward

We had not begun writing our formal, deliverable report when our work with the Joint Fire Science Program (JFSP) ended. We knew that writing the full report would be a considerable undertaking to distill our information into a succinct, professional, usable document. While we have tried to make this document as useful and readable as possible, it is not a formal, edited, fully vetted document. This report also does not address all of the topics planned for the formal report, and can not cover the topics to the depth planned for the formal report[1].

The bulk of the SEI's work for JFSP is captured the attached documents and presentations. It is important to understand, however, that many of these are SEI internal working documents that were not intended for public release. (Due to the shortened nature of the report preparation, it is not an exaggeration to also characterize this report as a working document.) These documents were created during the execution of our work and are therefore part of our body of work, but as working documents they in particular have not been edited or vetted. They are attached to help understand the direction of our work as it relates to our recommendations but they are not intended, nor are they authorized, for public release.

ATTACHMENTS TO THIS REPORT

Delivered Papers and Presentations

- *JFSP Software Tools & Systems (STS) Study: Phase I Results*, the delivered presentation
- *Inventory Slides For Boise Advisory Council Meeting*, the delivered presentation
- *JFSP Software Tools & Systems (STS) Study: Overview to JFSP Governing Board*, the delivered presentation
- *Quadrennial Fire Review Research Forum: Considerations for Science & Technological Change & the Future of Fire Management*, the delivered presentation
- *JFSP Software Tools and Systems Study Scenario Interviews: Summary Report*, the summary report from the effects interviews

[1] As examples, several of the topics – such as the investment criteria and investment recommendations – were not scheduled until the latter half of our work, and therefore are presented in a very limited manner.

- *The Future of Wildland Fire and Fuels Management Workshop Report*, the summary report for the futures workshop
- *Changing Information Approaches*, *Knowledge Sharing*, *and Organizational Structure*, the graphic wall chart created during the futures workshop
- *Interim Status Brief*, the delivered presentation
- *Interim Findings and Recommendations,* the delivered document
- *SEI Work Plan,* the original contract Work Plan

Working Documents & Presentations

Related to BlueSky

- *BlueSky Framework*, a working paper describing our analysis of BlueSky
- *BlueSky*, a working presentation describing our analysis of BlueSky

Related to the Demand Workshop

- *JFSP Demand*, a working paper created for the workshop describing sample wildland fire demands
- *JFSP Metrics Report Chart*, a working presentation created for the workshop outlining potential metrics for JFSP
- *DOTMLPFS Wheel*, a working document created for the workshop showing our assessment of the wildland fire community in the DOTMLPFS categories
- *JFSP NEED/Fit Table*, a working paper created for the workshop showing the data supporting the DOTMLPFS Wheel
- *List of Uncertainties (adapted from Phase I Effect Interviews),* a working document created for the workshop
- *Value Profiles, Orchestration/Synchronization, and Critical Capabilities*, a working document created for the workshop

Related to Framework Architectures

- *Draft 4: Framework Architectures: Using Stack Architectures to Address Issues in Opportunistic Software Development*, a working document describing framework architectures

Related to Middle-Out Modeling

- *First Analysis with Stratification and landscapes – Middle-out Outputs*, a working presentation created for interviews/workshops with wildland fire community members

- *Middle-out 4 color*, a working presentation created for interviews/workshops with wildland fire community members
- *Middle-out Modeling*, a working presentation created for interviews/workshops with wildland fire community members
- *Preliminary Middle-out Modeling Analysis*, a working presentation created for interviews/workshops with wildland fire community members
- *Middle-out demand, hierarchy, structure/function, synchronization, trace, and combined*, a series of diagrams created for interviews/workshops with wildland fire community members

Related to Projective Analysis (PAN)

- *Working notes: effects interviews to PAN (effects ladders) using dilemma formation and analysis*, a working presentation created for interviews/workshops with wildland fire community members
- *Visual PAN Modeling*, a working presentation created for interviews/workshops with wildland fire community members

Other Papers & Presentations

- *Presumed Federal Wildland Fire Community SOA Environment*, a working document created for background
- *Governance,* a working document created for background
- *Tool, System and Portal List,* a working document created for background
- *Software, System and SoS Architectural Issues,* a working presentation created as a background document for the interim outbrief
- *Service Oriented Architecture: Basic Issues,* a working presentation created as a background document for the interim outbrief
- *Interim Status Brief 19 Feb 2008 backup,* a working presentation created as a background document for the interim outbrief
- *JFSP Software Tools & Systems (STS) Study: Overview,* a working presentation created for interviews/workshops with wildland fire community members
- *NWFEA and SEI Study Relationships: Informal Talking Points,* a working presentation created for interviews/workshops with wildland fire community members

Background Documents (Limited Selection)

- *SoS Engineering and the Pragmatics of Demand*, a published paper discussing the pragmatics of demand – a form of interoperations needed to address the variety of demand situations encountered in systems-of-systems
- *Incorrect SOA Assumptions Can Lead to Mission Disaster*, a published presentation delivered at the Systems & Software Technology Conference 2007
- *Quality Attributes and Service-Oriented Architectures*, a published Technical Note CMU/SEI-2005-TN-014
- *Four Pillars of Service-Oriented Architecture*, a published article that appeared in CrossTalk, The Journal of Defense Software Engineering, September 2007

Overview

BACKGROUND

The Software Engineering Institute's (SEI's) engagement with the Joint Fire Science Program (JFSP) was originally intended to extend from April 2007 until December 2008. Our original tasking for JFSP could be characterized as

- help pick the "best-of-breed" of the wildland fire community's existing software tools and systems
- help assemble the best-of-breed software tools and systems into a system-of-systems (SoS)
- help "industrialize" the best-of-breed software tools and systems
- help plan how to best research, develop, and deploy new tools and systems in the SoS future

Implicit in this initial approach was the shared assumption by the SEI and JFSP that a reasonably small set of the existing software tools and systems – if properly arranged – could be sufficient for the demands facing the wildland fire community. This was more than an assumption – it underpinned this approach. As we discovered, however, this was not to be the case.

As we began our work, our focus was on understanding the needs of the wildland fire community, as well as to characterize some of the software tools and systems currently in use. We knew from experience with other government and commercial organizations that this understanding was critical for us (or any outside organization) for success. The major activities during this period included

- workshops and extensive interviews with a broad spectrum of wildland fire community members, to understand the wildland fire mission drivers
- participation in on-going wildland fire community activities such as the smoke roundtables, also to understand the wildland fire mission drivers
- Projective Analysis (PAN) modeling of current software tools and systems from the Pacific Wildland Fire Sciences Laboratory and the Missoula Fire Sciences Laboratory

We soon discovered that the number of software tools and systems was substantially larger than was first presented to us, and was growing. Also, the management of the existing tools and systems as well as the research into, and the introduction of, new tools and systems, was far more impaired than we envisioned, as evidenced by researchers doing the productization, training, and support of the tools and systems. Numerous documents confirmed there was significant duplication in the tools and systems, inadequate training, insufficient configuration management, etc[2]. We also discovered that the variety of end-users was far more diverse than we understood and included not just the six Federal agencies, but also included states, counties, cities, commercial companies, private citizens, etc.

PRESENT AND FUTURE CHALLENGES

Most importantly, however, we learned that the operational situations faced by the wildland fire community were dynamic and unpredictable for a variety of reasons such as climatic shifts, vegetation build-up, population shifts, etc. The operational environment was made more complex by the distances involved – activities frequently involved people working at disparate sites away far from an event as well as people on site working with local communities and interests. When variations due to different geographic regions, seasonal differences, different infrastructure and property values at risk, etc., were considered, the range of complexity grew even larger. Add the characteristic that these variables can combine in almost any combination, and each situation becomes nearly unique.

This complex mission already challenges – and in some cases overpowers – the community's existing software tools, systems, and data sets. In addition, there are already "known" challenges that will stress the system further – such as data fusion, forest succession, tighter health-related smoke and particulate matter regulation, wildland "urbanization", and increased personal legal liability (to name only a few)[3].

Forming the background for all of this were the "unknown" challenges – potential present and future technical, economic, political, social, etc. drivers that were outside the community's control. To characterize these, we conducted an "alternative futures workshop". This produced additional considerations such as a slashed budget due to a significant, long-term economic downturn, reduced personnel stemming from social changes that result in fewer recruits, crushing limits on

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[2] For example, see Chapter 3 FINDINGS EXECUTIVE SUMMARY of the Department of the Interior Enterprise Architecture (IEA) Wildland Fire management Modernization Blueprint, Version 1.1, April 2005

[3] For more information, please read the attached document *JFSP Software Tools and Systems Study Scenario Interviews: Summary Report*

carbon emissions, or financial market demands from a global carbon market (to name only a few)[4].

GENERAL OBSERVATIONS

As we examined the results of our interviews, workshops and readings, several key observations emerged about how the wildland fire community needs to use information, both now and in the future.

Information Needs

*Information needs will be **more distributed and broader based**. The demand for information will come from a greater, more-diverse group of users both inside and outside the traditional wildland fire community. Information will also be supplied by a greater, more-diverse group of suppliers, also inside and outside the traditional wildland fire community. An example of an information need from a non-traditional – but potentially very powerful – user would be the needs of the financial markets regarding the wildland carbon release and uptake in a possible global carbon market.*

Information Use

*Information will be used in a **wider variety of contexts** – not only operational and planning decision support, but for non-wildland environmental issues such as public health issues, policy making, litigation, media stories, business/commercial investment, etc. Also, information could – should – be a powerful vehicle for collaboration, and for establishing a common view or vision.*

Information Quality

*Information **reliability**, **consistency**, and **credibility** are critical.*

RECOMMENDED THEMES FOR SUCCESS

Considering the impact of these observations, as well as our new understanding of the existing wildland fire environment, we felt that creating a system-of-systems from the current amalgamation of software tools and systems was not realistic.

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4 For more information, please read the attached document *The Future of Wildland Fire and Fuels Management Workshop Report*

We believed that a significant change was needed to enable the wildland fire community to meet user's current and future needs. We presented this change to the JFSP Governing Board in the context of four "themes":

The wildland fire and fuels management community needs a shift in the science focus

The science program needs to extend its focus in a way that parallels the shift to distributed collaboration. Currently, the wildland fire community focuses on tools, systems, and data sets in a predominantly fire-behavior framework. This needs to extend to the challenges associated with developing systemic understanding of fuel growth and eco-system dynamics within a changing wildland urban interface (WUI) context. In particular, there needs to be particular emphasis on a methodological approach to simulation methods and data fusion across varying scales of ecosystems and scope of observations. This approach will rely heavily on cooperative action research or situated research methods.

The wildland fire and fuels management community needs a shift in the investment focus

Currently, the wildland fire community views tools, systems, and data sets as independent entities, and justifies investments in terms of their independent use. However, these tools, systems, and data sets need to be viewed in a net-centric fashion where they are combined into composite capabilities supporting the full range of ecosystem management activities. This requires investments be driven from the perspective of the user situations being supported, rather than the particular functionality being supplied.

The wildland fire and fuels management community needs a platform and approach that supports distributed collaboration

As the operational users described to us, fuels management and risk mitigation have an ongoing need for data fusion and require a distributed approach to collaboration. Because of the variety of operational contexts, it is impossible to centrally predict or resource the exact sets of models, tools, or data sets needed for each situation. This requires collaborative tools supporting net-enabled methods of analysis. This flexible and extendable integration framework (what we call framework architectures) will allow tool developers or sophisticated users to rapidly configure, calibrate, or extend Web-enabled capabilities to meet needs of a specific operational situation (commonly called situational applications or mashups).

The wildland fire and fuels management community needs methods for creating, publishing, and managing appropriate Web-based Services[5]

> *If these Services are driven by the suppliers (a supply-side approach), the merits of the individual Services will be emphasized, within the particular interests of the supplier. In contrast, if these Services are driven by the users (a demand-side approach), developing processes of user validation and supporting the emergence of new forms of user collaboration will be emphasized, within the presumption of a multi-sided market[6]. A demand-side approach uses standards and infrastructures supporting publication to focus on developing communities of use, which enable the widest possible population of suppliers to meet the user needs.*

NOTE: It is important to understand that the issues involved in the last two themes is beyond what a traditional system (including a "traditional" Service Oriented Architecture, or SOA approach) can effectively support.

REFRAMING

Realizing that the initial assumptions on which our work was based were not correct, we reframed of our work. We presented our findings and recommendations, as well as our plans for the balance of our work, to the JFSP Governing Board in February 2008[7]. After discussions following our presentations, however, both the SEI and the JFSP agreed that the work we proposed was not aligned with the JFSP's current goals and objectives for our work. As such, the SEI and the JFSP agreed to conclude the engagement with this informal report[8], which would include:

- The final report from our interviews with members of the wildland fire community
- The final report from the alternatives future workshop

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[5] This last theme will be directly affected by the Department of the Interior's (DoI) and the Department of Agriculture's (USDA) implementation of a service oriented architecture (SOA) approach using Web-based Services.

[6] This is frequently an "open source" approach to respond to users' needs.

[7] All of our findings and recommendations as of February 2008 are attached to this report.

[8] By "informal", we mean that this report is not an official Technical Note or Special Report, as defined by the SEI. The formal report writing portion of our original contract had not yet begun when the SEI and JFSP agreed to conclude the engagement. As such, this report is a quick turnaround effort that has not gone through a formal review or editing process. In particular, the report has not been vetted for "fair use" of the sources cited in the report. In addition, the sources are informally cited inline using footnotes, not bibliographies.

- An elaboration on the roles and responsibilities of the "communities" we said were needed for success
- A description of the characteristics and components of a collaboration support platform
- A description of mission threads including our thoughts on mission threads within the wild-land fire community, including mission threads for BlueSky
- Draft research investment criteria, as well as draft research investment recommendations
- Our findings and recommendations
- All of our presentation files

STRUCTURE OF THE REMAINDER OF THIS REPORT

This report will not repeat the information in the attached documents and presentations *per se*. This report will, however, provide additional information and background needed to better-understand our recommendations in two key areas:

- Framework architectures
- Data fusion

As stated previously, the report will also cover the communities, collaboration support platforms, and mission threads. These will be followed by our draft investment criteria, draft investment recommendations, and a brief summary.

1 Framework Architectures

One of our key recommendations was that the wildland fire community adopt a framework architecture. The purpose of this section of the report is to provide additional background on this topic.

A BRIEF DESCRIPTION OF THE DIFFERENT ARCHITECTURE FRAMEWORK TYPES

The attached SEI working document *Framework Architectures: Using Stack Architectures to Address Issues in Opportunistic Software Development* presents an overview of Framework Architecture 1.0, Framework Architecture 2.0, and Framework Architecture 3.0. While readers of this report need to read this document to fully understand the three frameworks, the introduction portion of the attached SEI working document *BlueSky framework*[9] briefly summarized the frameworks (now called Type I, Type II and Type III).

Extracting from this summarization:

- Type I framework architectures are typified by an SOA infrastructure – they provide Services with well-defined behaviors
  - On-line banking is an example of this type of framework architecture
- Type II framework architectures are associated with situational applications and with mashups – they allows users to customize Services and orchestrate Service compositions to meet a particular situation *in an environment with shared assumptions about the domain*
  - Assembling a report on a particular telephone customer across different types of service to diagnose an intermittent fault is an example of a situational application (situational applications are generally seen as applications internal to an enterprise)
  - assembling and graphically presenting different kinds of neighborhood data from different sources while looking for a new house is an example of a mashup (mashups are generally viewed as applications using some or all sources external to an enterprise)

[9] We strongly feel that BlueSky is an important project for the wildland fire community. This is not only because of the important functionality it provides users, but for the equally important architecture framework concepts it is putting into practice. BlueSky is also addressing critical scale commensurability and scope consistency issues that will be addressed in further in the next chapter.

Put another way, Type I framework architectures are concerned with delivering particular Services out of an infrastructure. Type II framework architectures support users' adaptations of those Services, but in ways limited by shared 'common sense' assumptions about the meaning of the data and processes in those assumptions. However, in neither of these does the *nature* of the situation affect the way the individual Services are customized, orchestrated or synchronized.

In Type III framework architectures, the nature of the situation *does* affect how the Services are customized, orchestrated or synchronized. In Type III framework architectures, meaning is no longer shared or common but is peculiar to the specific situation being addressed. For an example, a doctor's interpretation of a patient's medical problem will affect the way in which the doctor brings together the results of different diagnostic tests with elements of the patient's medical history. Another example is a warfare officer's expectation of a threat will affect the way they bring together sensor and track data.

As an example in the wildland fire domain, a planner's expectations for a mitigation strategy protecting a local community will affect the way the planner brings together fuels data with overlapping geospatial data sets relating to the forest's history as well as the development potential. In each case, the particular dynamic characteristics of each situation affect the way the data and services are used produce useful output.

BlueSky as an Example

Addressing a specific wildland fire community tool, the *BlueSky framework* working document and the *BlueSky* working presentation make the argument that BlueSky is at least Type II framework architecture (an open-sourced 'mashup' architectural framework) and has significant Type III framework architecture characteristics. We were not able to fully explore BlueSky before our work ended, so we can not make any judgments about BlueSky's ability to serve as a model for the rest of the community. Even if that is not the case, the experience and knowledge gained by the BlueSky team is precisely the experience and knowledge the community will need as it moves forward with our recommendations.

THE UNDERLYING NEED FOR SERVICE ORIENTED ARCHITECTURE

As discussed above, there are three types of framework architectures. What was not explicit in our recommendations, nor in the attached documents and presentations, is the dependencies between the three types. Type I framework architectures (providing Services) are necessary for Type II framework architectures (composing Services to meet a specific situation based on shared assumptions). Type III framework architectures (which, as this is written in 2008 is a leading edge technology) in turn depend on having a Type II framework architecture (and therefore a Type I).

As we described, Type I framework architectures provide Services with well-defined behaviors. This is echoed in our theme that the wildland fire community needs methods for creating, publishing and managing appropriate Web-based Services. Both of these have the unstated assumption that the wildland community needs to adopt a service oriented architecture (SOA) design pattern.

This is not a new idea for the wildland fire community. In the attached SEI working document, we attempted to summarize the wildland fire community's SOA approach[10]. Drawing from the paper, the federal wildland fire community will implement the SOA design pattern using Web-based services. The community will also use an Enterprise Service Bus (ESB), and employ several widely-used standards, and all or parts a commercial, integrated SOA tool suite. This is a fairly standard approach, and if properly executed can efficiently support the community.

However, as we talked with members of the wildland fire community during our work, SOA is not universally understood. In fact, many people we spoke to were unfamiliar with SOA, even as they were very familiar with using "SOA" in the public domain (see the example in the *Framework Architectures: Using Stack Architectures to Address Issues in Opportunistic Software Development).* As an understanding of SOA is a critical foundation for many of our recommendations, we will present a brief overview of SOA and Web-based Services (Type I), as well as situational applications and mashups (Type II).

NOTE: These descriptions are deliberately brief and only meant to provide a high-level context in which to understand our recommendations. Readers of this report are encouraged to read further about each of these topics.

SOA DESCRIPTION[11]

There is no single, official definition of SOA. For this report, this definition will be used

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[10] Our work ended before we could confirm these assumptions.

[11] This section is principally adapted from the attached documents *"Quality Attributes and Service Oriented Architectures";* Liam O'Brien, Len Bass, Paulo Merson; September 2005; CMU/SEI-2005-TN-014 and *"Four Pillars of Service-Oriented Architecture (SOA)"*; Grace A. Lewis, Dennis B. Smith Carnegie Mellon University, Software Engineering Institute, 4500 Fifth Ave., Pittsburgh, PA

- "A Service-oriented architecture (SOA) is an architecture built around a collection of Services with well-defined interfaces. A Service is a coarse-grained, discoverable, and self-contained software entity that interacts with applications and other Services through a loosely coupled, synchronous or asynchronous, message-based communication model. A system or application is designed and implemented using functionality from these Services as part of its mission. SOA connotes a style or approach for developing a system. Thus *SOA* is not an alias for *system*, but rather describes a particular way in which systems might be constructed." – *SEI, Governance Issues for a Service-Oriented Architecture*[12]

Perhaps the most important point in this description is the final one – SOA is not a system, but is a particular way in which a system might be constructed. Not included in this definition is another key element – not everything is a SOA-based system must be a Service. For the wildland fire community as well as any organization embarking on SOA, it is critically important to identify what piece of functionality will become Services and to define the interfaces of those Services.

A SOA-based system is composed of

- *Services*: These are reusable components that represent business or mission tasks, such as weather, fuel bed loading, sensor placement, or material lookup. Services can be globally distributed across organizations and reconfigured to support new tasks or missions. They are reusable because they can be used by many business processes or mission threads. They usually provide coarse-grained functionality, such as material lookup as opposed to finer-grained functionality such as material exploded parts diagram lookup.
- *Service Providers*: These are clients who create the functionality provided by the Services, such as developers or even other Services.
- *Service Consumers*: These are clients for the functionality provided by the Services, such as end-user applications, systems, or even other Services.
- *SOA Infrastructure*: The infrastructure connects Service consumers to Services. It usually implements a loosely coupled, synchronous or asynchronous, message-based communication model, but other mechanisms are possible. The infrastructure often contains elements to support Service discovery, security and other operations. A common SOA infrastructure is an Enterprise Service Bus (ESB) to support Web Service environments. The Army's System of

[12] news@sei column Eye on Integration *Governance Issues for a Service-Oriented Architecture*; Dennis Smith and Pat Place, 2006

Systems Common Operating Environment (SOSCOE[13]) and DISA's Net-Centric Enterprise Services (NCES[14]) are two examples of SOA infrastructures within DoD.

We have already said that a Service interacts with other Services through a message-based communications model. Common communications models include

- Web Services using Simple Object Access Protocol (SOAP) and Web Services Description Language (WSDL)
- Message-oriented middleware (MOM) such as IBM WebSphere® MQSeries®[15]
- Publish-subscribe system such as Java Messaging Service (JMS)

A typical example of a discoverable and coarse-grained Service in a commercial environment is a credit card validation Service. By "discoverable", we mean that Services must be able to be discovered at both design time and runtime, not only by unique identity, but also by interface identity and type of Service. By "coarse-grained", we mean that Services implement more functionality and operate on larger data sets, as compared to components in component-based design. If Service interfaces are too coarse-grained, consumers will receive more data than they need in their response message. If Service interfaces are too fine-grained, consumers will have to make multiple trips to the Service to get all the data they need[16].

WEB-BASED SERVICES[17]

There is also no universally accepted definition of Web Services. The SEI describes Web Services as an instantiation of a SOA where all of the following apply

- Service interfaces are described using Web Services Description Language (WSDL).

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13 http://www.dsci-usa.com/document/Emeryarticle.pdf

14 http://www.disa.mil/nces/

15 Reportedly adopted by the USDA – see the attached working document *Presumed Federal Wildland Fire Community SOA Environment*

16 This is a significant issue, as identifying granularity appropriate for a given application requires considerable effort.

17 This section of the report is adapted from information published on "http://www.sei.cmu.edu/isis/guide/technologies/Web-Services.htm"

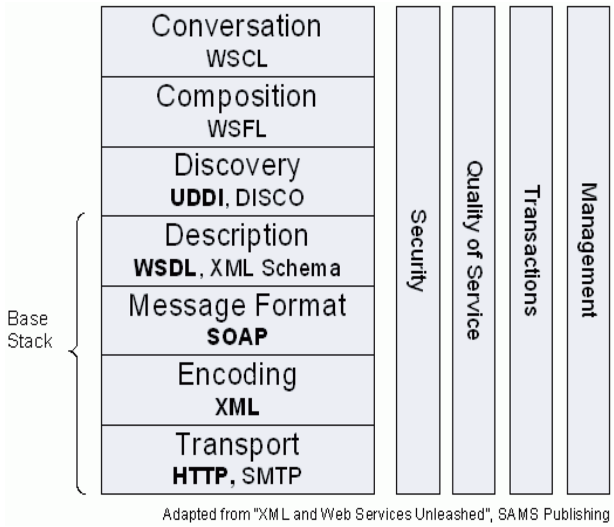
- payload is transmitted using Simple Object Access Control over HTTP (Hypertext Transfer Protocol).
- Universal Description Discovery and Integration (UDDI) is optionally used as the directory Service.

The growing success of Web Services is due to a number of factors, such as

- Systems can interact with one another dynamically via standard Internet technologies
- Services are built once and reused many times
- Services can be implemented in any programming language
- Service consumers do not need to worry about firewalls because communication is carried over HTTP
- Systems can advertise their capabilities for other systems to use. For example, Amazon Web Services allows systems to access catalog data, manage the shopping cart, and initiate the checkout process via Web Services
- Standards such as BPEL4WS (Business Process Execution Language for Web Services), WS-Security, WS-Routing, WS-Transaction, WS-Coordination, and WSCL (Web Services Conversation Language) are working toward the automatic discovery and composition of Web Services

The success of Web Services is based on the availability of technologies that support it, as indicated in the figure below. Items in bold indicate the more standard and commonly used technologies. The vertical bars indicate that elements of Security, Quality of Service, Transactions, and Management have to be present in all layers of the protocol stack[18].

[18] Other authors merge "Conversation" and "Composition" into "Services Orchestration/Choreography" or similar.



SITUATIONAL APPLICATIONS

Situational applications (SAs) are applications that are quickly composed from Services to address a particular situation facing a user (hence the name). As with SOA, there is no official definition of SAs, but it is generally accepted that SAs are only composed from Services available within the enterprise. SAs that use Services from outside the enterprise are generally termed *mashups*, which are described in a subsequent session.

IBM[19] describes situational applications as

- supported by a SOA foundation
- developed to address a situation at hand (hence the name situational applications)
- assembled from existing building blocks (called consumables by IBM)
- often built by non-traditional, casual programmers with little up-front emphasis on reliability, scalability, maintainability, and availability

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[19] This section of the report is extensively drawn from *SOA meets situational applications, Parts 1: Changing computing in the enterprise*; http://www.ibm.com/developerworks/WebServices/library/ws-soa-situational1/ and *SOA meets situational applications, Part 2: Building the IBM Situational Applications Environment;* http://www.ibm.com/developerworks/WebServices/library/ws-soa-situational2/index.html; Luba Cherbakov, Andy Bravery, Aroop Pandya, IBM August 2007

- habitually use pre-existing software, often created and sources from a third party via a public interface
- developed in short, iterative cycles measured in days or weeks rather than months or years, focusing on time-to-value
- evolved as requirements change, significant changes may lead to a new SA as it's sometimes just easier to develop a new SA than to update the one in use
- usually information-centric

MASHUPS

IBM refers to mash-ups[20] as a new breed of situational applications that solve business challenges that were either low priority or unaffordable from an enterprise perspective. (We are **not** suggesting that the wildland fire community embark on this path to address low priority challenges – we recommend this path to solve the previously *unaffordable* but very real challenges. However, it is gratifying to note that mash-ups also help with the mundane.)

In his 2007 presentation *Web 2.0 – Mashups for the Knowledge Worker*[21], Tony Fricko describes mashups by first ascribing these characteristics to situational applications

- rapidly created (less than 5 minutes) to address an immediate need of an individual or community
- typically but not necessarily short-lived (a "just-in-time, just-for-the-time" solution)
- just good enough
- informal (lacks product quality look and feel)

Friko then states that mashups can be a form of a situational application that

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[20] Adapted from "Mashups: The new breed of Web app", www.IBM.com: … a mashup Web site is characterized by the way in which it spreads roots across the Web, drawing upon content and functionality retrieved from data sources that lay outside of its organizational boundaries … a mashup is an unusual or innovative composition of content (often from unrelated data sources), made for human (rather than computerized) consumption.

So, what might a mashup look like? The ChicagoCrime.org Web site is a Web site that mashes crime data from the Chicago Police Department's online database with cartography from Google Maps. Users can interact with the mashup site, such as instructing it to graphically display a map containing pushpins that reveal the details of all recent burglary crimes in South Chicago. The concept and the presentation are simple, and the composition of crime and map data is visually powerful.

[21] Web 2.0 – *Mashups for the Knowledge Worker* Assemble – Wire – Share; IBM 2007

- is comprised of 2 or more disparate components that are bound together through content
- yields a new utility by seamlessly combining content from more than one data source with behavior to form a new integrated experience

IMPLICATIONS FOR JFSP

As we said, DoI and USDA are implementing the SOA design pattern using Web-based Services (Type I). In the documents we reviewed, however, we found no mention of situational applications and/or mashups[22]. While we would have liked to see these addressed, we were not surprised by their omission. Situational applications and mashups support users at the edge – on the fire line, if you will – while the enterprise SOA and Web-based Services efforts are geared towards core Services designed for efficiency and economies of scale.

So where does this put JFSP? With its close ties to both developers and operational users, as well as its investment capability, we feel that JFSP is in a unique position to understand and invest in wildland fire situational applications and mashups efforts. We also feel that JFSP should provide funding for the data fusion research required for Type III framework architectures[23].

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[22] And while we didn't expect to find any, we also did not find any mention of a Type III framework architecture.

[23] A SOA-based infrastructure is a necessary but not sufficient foundation for a Type III framework architecture

2 Data Fusion

Data fusion is a key research area needed for our recommendations for the wildland fire community to adopt a Type III framework architecture. The purpose of this section of the report is to provide additional background on this area.

The GAO report on geospatial information[24] listed these challenges related to bringing together geospatial data in a way that is relevant to wildland fuels and fire management:

1. Geospatial data is not consistently available and not compatible across different agencies, states and local entities.
2. Agencies are developing multiple duplicative systems, many of which are not interoperable.
3. There are inadequate infrastructures for accessing and manipulating data.
4. There exist major differences in the quality of GIS know-how available locally.
5. There is low awareness within the wildland fire community of the new products and services available.

The GOA report recommended the development of an enterprise architecture to address these challenges. It is true that a Type I framework architecture could have a significant impact on challenges 1, 2 & 3 above. If the framework architecture supports Web-enabled use (such as the SOA and Web-based Services approach on which DoI and USDA are embarking), it could also meet challenges 4 & 5 above (at least for reporting and visualization purposes).

But this alone will not meet the *data fusion* needs of the wildland fire community. As discussed in more detail the attached SEI working paper *Framework Architectures: Using Stack Architectures to Address Issues in Opportunistic Software Development,* data fusion is a problem being faced by many communities. As we use this term, data fusion is beyond situational applications and mashups, and is into the realm where data and processes from disparate sources are composed together in ways that are particular to a situation. This involves issues of scale commensurability and scope consistency.

[24] *Geospatial Information Technologies Hold Promise for Wildland Fire Management, but Challenges Remain*: United States General Accounting Office Report to Congressional Requesters, GAO-03-1047, September 2003

SCALE COMMENSURABILITY AND SCOPE CONSISTENCY[25]

Consider the example of managing the risks arising from the effects of different climactic and environmental changes on wildland ecosystems. Situational applications and mashups created in this environment frequently rely on geospatial data from models and data sets that have different sources and primary uses. The key problem in data fusion is the ability to ensure *scale commensurability* (scales of observations) and *scope consistency* (scopes of these observations) across all of the models, tools and datasets used to support the situational applications and mashups. Both of these – scale commensurability and scope consistency – place an emphasis on the *nature* of the observations being fused.

A typical approach to data fusion is based on defining the *ontology* of the data being fused in terms of its definition. This approach attempts to semantically match[26] inputs and outputs and assumes semantic interoperability and a unified classification of spatial features[27]. However, experience has shown that this approach produces definitional structures of extraordinary complexity that have yet to yield their promise of automated translation[28].

Present research indicates that the most available approaches to semantic integration provide ad-hoc, non-systematic, and subjective manual mappings[29]. Therefore, we recommend that *the way the data is to be used* form the semantics of the data fusion process, and that the wildland fire community place its emphasis on establishing commensurability and consistency there.

Our recommended approach is to model the way the data is to be used in order to define the semantics of the data fusion process. This places the emphasis on establishing the ontology *of the observations themselves* and the scale commensurability and scope consistency *between inputs and outputs at each stage of the modeling process*. This subordinates the formal semantics to the pragmatics of the modeling situation.

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[25] This section of the report is principally drawn from the attached SEI working document *BlueSky framework*

[26] “Sematic Integration of File‐based Data for Grid Services”, Woof et al, 2005. Proceedings of the Fifth IEEE International Symposium on Cluster Computing and the Grid, Vol 1.

[27] By Yuxiao Li and George Benwell, presented at SIRC december 2002.

[28] “Ontology Mapping: the state of the art”, Kalfoglou and Schorlemmer, The Knowledge Engineering Review, 18(1) pp1□31 2003.

[29] “A unified ontological framework for semantic integration”, Marinos Kavouras, Internationa Workshop on Next Generation Geospatial Information, Oct 2003.

Another distinguishing characteristic of data fusion in wildland fire environment is the presence of allometric[30] scaling across the inputs and outputs of its models. This indicates the complexity in the systems being observed, and is what prevents the use of a general ontology (*qua* common sense) in how data is fused across models. It is this complexity that challenges the universal approach to ontology.

The attached working paper *BlueSky framework* has a more in-depth look at the issues of scale commensurability and scope consistency. One highlight from the paper is shown below. The figure[31] shows a BlueSky instantiation – the geospatial domain to which the model chain is being applied, the resolution of the spatial data, the forecast period over which projections of smoke dispersion are to be made, the consortium that is defining what is pragmatically relevant to their needs, and the type of situation being supported.

Domain	Resolution	Forecast Period	FCAMMS	Forest Service Research Station	Wildfire	Rx fire	Ag fire	RAINS	In operation since
Northwest	12 km 4 km	72 hrs 48 hrs	NWRMC	PNW	X X	X X	X X	X X	2002
California / Nevada	4 km	48 hrs	CANSAC	PSW	X	M	—	*	2004
Northeast	12 km	48 hrs	EAMC	NRS	X	M	—	*	2004
Rocky Mountain	12 km 8 km	48 hrs	RMC	RMRS	X X	M M	— —	* *	2004
Southeast	12 km	48 hrs	SHRMC	SRS	X	M	—	*	2006
West (demo)	36 km 12 km	48 hrs	NWRMC/ RMC	RMRS/ PNW	X X	M M	— —	X X	Operated in 2005

Ag fire = agricultural fire.
Rx fire = prescribed burning.
X = in operation.
M = manual only.
— = not yet available.
* = implementation of RAINS is in progress as of June, 2006.
FCAMMS = Fire Consortia for the Advanced Modeling of Meteorology and Smoke.
PNW = Pacific Northwest Research Station
PSW = Pacific Southwest Research Station
NRS = Northern Research Station
RMRS = Rocky Mountain Research Station
SRS = Southern Research Station

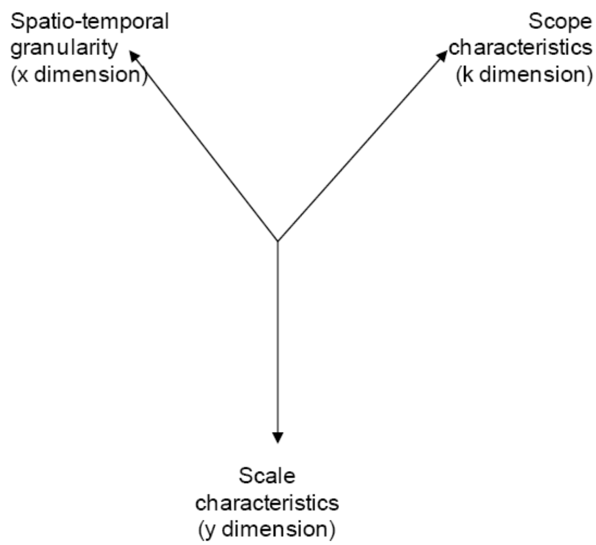
We can now define three dimensions along which to describe the model chain:

30 Allometric scaling assumes that the relationships between observations of different scale and scope are subject to some form of (non-zero) power law reflecting the underlying complexity of the relationships. For example, see "Allometric Scaling Theory applied to FIA Biomass Estimation", D>C> Chojnacky, http://nrs.fs.fed.us/pubs/gtr/gtr_nc230/gtr_nc230_096.pdf

31 "BlueSkyRAINS West (BSRW) Demonstration Project Final Report 2006"

- It has to be able to work with whatever spatial and temporal granularity the data has. This means understanding the resolution of the observations from which the data is founded, and their accuracy with respect to whatever resolution is claimed. We refer to this as the x-dimension of the observations used.
- Secondly, it has to be able to work with whatever type of scale has been used, against which the observations have been measured, and the precision of those measurements. One obvious issue here is that the precision with which the measurements are expressed should not exceed the accuracy of the observations themselves. We refer to this as the y-dimension of the observations used. By type of scale is here meant the familiar distinction between nominal, ordinal, interval and ratio scales, which carry with them assumptions about the way in which assertions may be made about what it is that is being observed.
- Thirdly, it has to be able to take account of the scope of the observation method and its significance. We refer to this as the k-dimension of the observations used. This scope is the ratio of the largest observation possible to the smallest observation possible, which is a function of the method of observation being used. This concept of scope is the other meaning of 'scale' in which what is being emphasized is the order of magnitude of the system about which assertions are being made. Thus the scale of landscape for an ant on a leaf is very different from that of an elephant: the scope of an ant's observations are very different to those of an elephant.

These three dimensions can be summarized in terms of the following figure, and provide the basis for characterizing the ontology of an observation.



This diagram graphically helps understand *scale commensurability* and *scope consistency*. In a situational application or mashup, the scales used by the different Services and data sets must be commensurable with each other, while their scope must be consistent. An important result of this assertion is that there must be a definable scaling relationship between the scales.

IMPLICATIONS FOR THE WILDLAND FIRE COMMUNITY

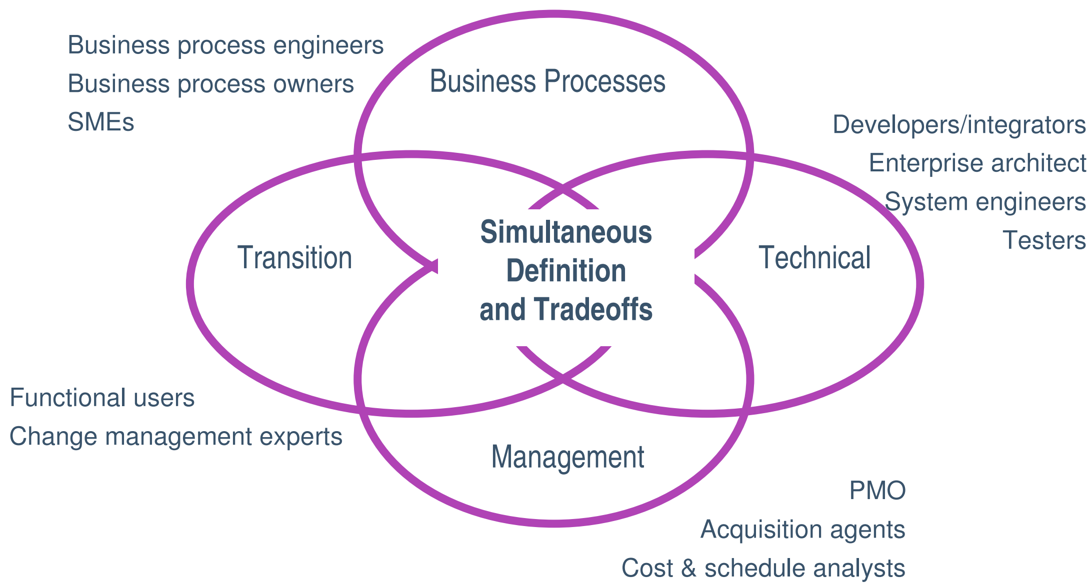
As we stated in the previous section, we believe that JFSP should understand and invest in wildland fire data fusion efforts.

3 Roles and Responsibilities of the Different Communities

As part of our final report, JFSP requested we further describe the roles and responsibilities of the various communities we discussed during our work. The purpose of this section of the report is to provide additional background on this area.

During the course of our work, we frequently mentioned the "different communities" or the "different perspectives". Over the course of our work, we refined this concept, in concert with ongoing research at the SEI. This meant that there were several versions of this concept presented in our work, several of them with noticeable differences. Rather than show all of these, this report will discuss the original version presented to members of the JFSP Governing Board in late 2006.

This four-community view is conceptually simpler than the five community view we showed in the latter part of our work. It is geared towards program management, and in some ways is not sufficient for the Type III framework architecture we recommend for the wildland fire community in the mid-term to long-term. However, its simpler structure and presentation makes it a better vehicle to introduce this topic to wider audiences.



- The business or processes or operational community "owns the need", whether it is planning a prescribed burn or reconciling the general ledger. This community also denotes requirements (including quality attributes such as performance, security, and reliability), end-user business processes, business drivers, and the operational environment.
- The technical community denotes the available and emerging tools, systems, and data sets and relevant standards. From an architecture and design perspective, this community denotes the essential elements of the system and the relationships between them (structure, behavior, usage, functionality, etc.)
- At a strategic level, the management community denotes the enterprise governance in which the system operates. At a tactical level, this community denotes the management aspects such as the cost, schedule, and risk of building, fielding, and supporting the solution to include the cost, schedule, and risk for changing the necessary business processes.
- The transition community denotes the change management processes that are required to successfully put the system into use[32].

This representation of the communities has one advantage over the five community model – the concept of simultaneous definition and tradeoffs is explicitly shown as the balancing function between the four communities. It is here that the competing interests of these communities must be balanced.

Behind this four community concept is that understanding that all complex systems begin as a vision or goal (no matter how much the federal acquisition system forces an early, detailed plan). However, much of the detail about the system can not be known at the start – the information simply isn't there. Detailed information is accumulated through the life of a program as the technical solution is explored and as users become more-aware of the capabilities of the evolving system, etc. This system also evolves as risks and opportunities associated with technical solution are discovered, or budget issues alter schedules, or changes in the mission alter requirements, etc. Each one of these affects the four communities.

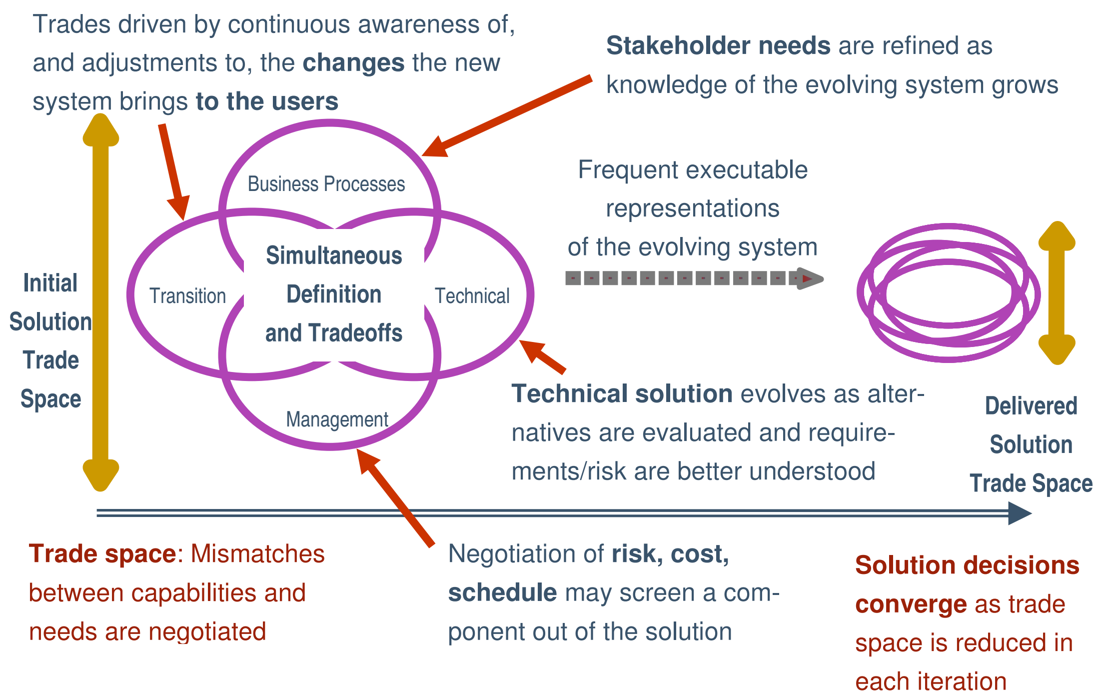
However, a decision made by any one of the communities in response to a change will both inform and likely constrain the decisions that can be made in another community. For example, an operational need may be stated in such a way that it cannot be satisfied by any known pre-existing component. Similarly, a potential tool or system may not be compatible with the organization's existing infrastructure or use a licensing strategy that would be cost prohibitive. The key is not to

[32] The technical community gets the product ready for the field; the transition community gets the field ready for the product.

proceed as if these changes will not occur – they must, in a healthy, responsive program of this nature. However, a program must proceed by balancing the changing needs of the four communities in a negotiated, give-and-take process.

Another aspect of the four community model is that the frequently over-looked community – the transition community – is specifically highlighted. All of the changes mentioned above – altering the technical solution, altering the schedule, or altering the requirements – directly affect how the system will be transitioned to the users. The needs of this community – understanding what people do today, what they will do tomorrow, and preparing them for the transition – must be considered as an equal partner to the other communities. If users can't use a system (ineffective transition processes), the failure is as great as if the system did not meet requirements (ineffective business processes), did not work (ineffective technical processes), or was cancelled because of budget overruns (ineffective management processes).

Sample tradeoffs as seen over time are shown below[33]:



[33] Albert, C and Brownsword, L; Evolutionary Process for Integrating COTS-based Systems (EPIC), presentation at ICCBS 2006

4 Collaboration Support Platform

As part of our final report, JFSP requested we further describe the concept of a collaboration support platform. The purpose of this section of the report is to provide additional background on this area.

At a basic conceptual level, a collaboration support platform is a framework architecture plus all of the associated processes needed to support the generation of operational effects. This includes services, data sets, models, tools, etc., made available to those who know how to compose, orchestrate, and synchronize the capabilities to address operational situations. It also includes the processes of collaboration between those with the know-how, which are required to satisfy the needs of the particular situation. Implicit in this definition is an underlying process which ensures that the capabilities of the framework architecture are the capabilities needed to support these processes of collaboration in a timely manner.

The type of framework architecture as well as the types of processes should be driven by the needs of the operational demands and environment. The degree to which these are inconsistent determines the size and nature of the gap between what is supplied and what is demanded – what we have characterized as the "hole-in-the-middle".

Where our work ended with JFSP, we had not reached the stage where we could say more about the detailed nature of the forms of collaboration support needed. Hence, we can only say

- a great deal of Type III activity is happening at the operational 'sharp end' (driven by necessity), whether or not it is currently being adequately supported by a framework architecture.
- data fusion **must** be better understood in this context.
- we had yet to start the research (or, as evidenced by this report, had not yet sufficiently analyzed and documented the existing interview materials) to be able either to bring the existing Type III activities into focus, or to identify the particular ways in which the existing tools, systems, and data sets fell short of supporting Type III activities. It was our view, however, that a large measure of the proliferation and fragmentation of tools, systems and data sets was a direct symptom of the current inadequacy of the support to Type III activities.

We hope that the following quote sheds some additional light:

Collaboration is one of the major requirements in today's life and business. We can find collaborative activities at different levels and with different extents. The range of involved fields is very wide, from classrooms to enterprises, and all demand appropriate support. In particular, information technology can provide such support, but it is not a trivial task. On one hand, collaborative systems may be complex, distributed, open, and dynamic applications; on the other hand, the human factor plays a very important role with respect to other application fields.

Collaboration is, for its own nature, distributed. Collaboration support systems must accomplish such distribution by exploiting appropriate technologies and must meet users' requirements while also evolving or adapting to the users' needs. Collaboration between different organizations can be achieved by the openness of the systems, a feature that could lead to global collaboration.

Technological advance in collaborative systems is limited. Human perception and feeling are perhaps more important for these systems to gain wide acceptance. Users are asked to collaborate in (possible slightly) different ways from usual collaborations, and social aspects must also be taken into account when designing collaborative systems. This is the reason why careful tests must be carried out to evaluate a system. This picture points out that collaboration support systems must be carefully developed[34].

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[34] Guest Editorial Special Issue on Collaboration Support Systems, IEEE Transactions on Systems, Man, and Cybernetics – Part A: Systems and Humans, Vol 36, No 6, November 2006

5 Mission Threads

As part of our final report, JFSP requested we further describe the concept of a mission threads. The purpose of this section of the report is to provide additional background on this area.

During the course of our work, we used the term "mission thread" to describe an end-to-end mission process. There is not a formal definition of "mission thread." A working definition used by the Naval Studies Board[35] is:

"A mission thread is a sequence of activities and events beginning with an opportunity to detect a threat or element that ought to be attacked and ending with a commander's assessment of damage after an attack."

A key point in this definition is that a mission thread begins even before a threat exists – it begins with putting in place the ability to detect a threat. Another key point is that the mission thread does not end with the cessation of activities; it ends after the activities have been assessed. Modifying this slightly, a definition of a mission thread for the wildland fire community could be:

"A mission thread is a sequence of events, activities and information flows beginning with *an opportunity to detect an aspect of the wildland ecosystem that needs attention,* and ends with *a manager's assessment of the impact of the ecosystem management activities*[36]."

The U.S. Army's Central Technical Support Facility, Fort Hood, TX, elaborates further on mission threads[37]:

A key point from this definition is that the mission thread encompasses all functionalities and capabilities needed to support the thread – everything touched by the thread, be it people, processes, or tools. It's also important to note that mission threads can be defined at multiple levels of abstraction and with varying granularity of detail depending on what is being characterized and ana-

35 Naval Studies Board (NSB) 2006 "C4ISR For Future Naval Strike Groups", The National Academies Press

36 "Needing attention" could be a fire, restoration, land use change, etc.

37 COL Charles McMaster, Director, CTSF, undated "Central Technical Support Facility" brief, http://www.testweek.org/Briefings/McMaster.pdf

lyzed, and for what purpose(s). For example, mission threads could be at a very high level of abstraction such as the lines of business (LOB)

- wildland fire
- recreation
- law enforcement
- finance

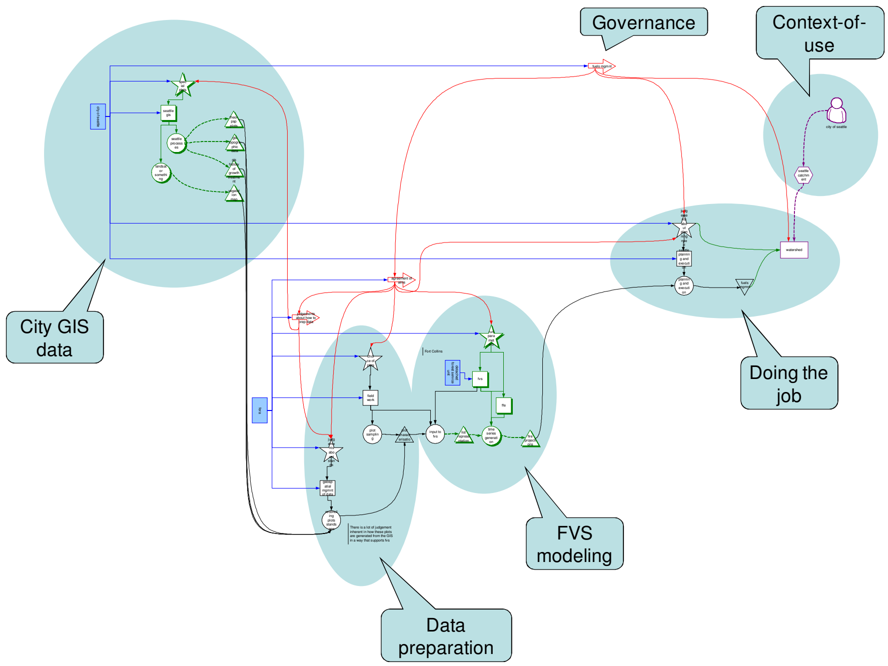
Mission threads could also be down to the level of a single incident response or planning exercise. The following hypothetical example is of a fire suppression mission thread[38].

- The wildland fire enterprise provides the underlying core infrastructure and services. These elements are based on an understanding of current and future wildland fire policies, trends, and needs. The data sources reside on servers owned by various government agencies, and accessible through public and private web sites. Associated tools and models also reside in various locations.
- Developers to make models, tools and data sets that are known to appropriately interoperate available to the operational users via the underlying core infrastructure and services. Developers also continually analyze the operational contexts-of-use so that a wide variety of geometries-of-use can be supported.
- Responding to a triggering event, an incident commander brings together multiple experts such as ecologists, fire and emission specialists, a GIS specialist, etc. Some of these experts are typical users, while other, more-experienced experts are power users.
- The experts draw upon a broad spectrum of data such as current satellite imagery data, current, historical and forecast weather data, biomass characterizations, fuel loading, current air quality values, etc. via the underlying core infrastructure and services. The experts also draw upon existing capabilities and applications available on the underlying core infrastructure and services.
- The experts also identify the need for a specific set of analysis tools to deal with the unique situation facing them. The power users among them access, orchestrate, and synthesize these tools and the associated data sets via underlying core infrastructure and services.

[38] This thread does not reflect capabilities that exist in the community today.

- However, some needs remained, so the request of the power users the developers composed additional data and tools and quickly made them available to the experts via the underlying core infrastructure and services.
- After the incident was resolved, users rated the available tools, and several of the unique applications created by the power users and developers were adopted by the enterprise and made available as part of the standard application pool.
- This process was executed under the processes and governance structure put in place by the senior mangers within the wildland fire community, and funded through the investment priorities set by the community.

Other examples of mission threads are in our PAN work, a sample of which is shown below.



6 Investment Criteria

THE NEED FOR SYSTEMIC WILDLAND FIRE ECOSYSTEM MANAGEMENT

One request made by JFSP for this report for investment criteria and investment recommendations, based on our work to date. While we understand the desire for this, it highlights two of our one of our chief concerns for the community

- the wildland fire community does not have a systemic ecosystem management approach that would allow investments to be to be adequately weighed and judged
- JFSP does not have a portfolio management or an investment analysis approach to characterize the economics of the costs of wildfires and the tradeoffs between mitigation and suppression

The ecosystem management and portfolio management approach(s) should also monitor each investment's progress. For research, some percentage of the projects invested in will not show positive results – this is inherent in a research environment. That being said, however, a process and criteria for terminating or continuing funding should be consistently applied across all projects. In our interviews, we found a number of instances where the community felt – correctly or not – that personalities rather than operational need, good research, or positive results determined funding. Further, we found a number of instances where JFSP board members seemed unaware of the value of projects that they were funding or had funded.

Draft Investment Criteria

As we stated, our work ended before we began the investment analysis portion of our work. These criteria, then, are generalized from the findings and recommendations presented to the JFSP Governing Board in February 2008.

> ***Is there an adequate description – appropriate to the stage of the work – of the roles and responsibilities related to this investment, including science and research, prototyping, development, support, transition, and maturation? Have the individuals or organizations cited for each role/responsibility agreed?***
>
> ***Does the investment align with JFSP's evolving ecosystem management practices?***

What role does the investment have in the evolution and support of a systemic understanding of fuel growth and eco-system dynamics within a changing WUI context?

How does the investment support a Type I framework architecture? Type II? Type III?

How does the investment support the "culture of reuse" that is needed for the wildland fire community to successfully adopt Type I, Type II, and Type III framework architectures?

Can the investment be used individually, as well as part of composite capabilities supporting the full range of ecosystem management activities (i.e., situational applications or mashups)?

How does the investment support data-driven simulation across varying scales and scopes?

How does the investment support data fusion across varying scales and scopes?

Has there been an adequate assessment of the cost effectiveness and effort required make this investment into a Service (either as a new investment, or as an investment to convert existing tools and systems to a Service)?

How is the additional expense of creating this investment as a Service justified within the ecosystem management practices?

Is the investment compatible with current DoI and USDA SOA and Web-based Services plans, governance, and activities?

Will the product of the investment use the core services provided by the core DoI/USDA SOA services (security, discovery, etc.)?

If the investment will be deployed as a Web-based service, is it semantically enabled?

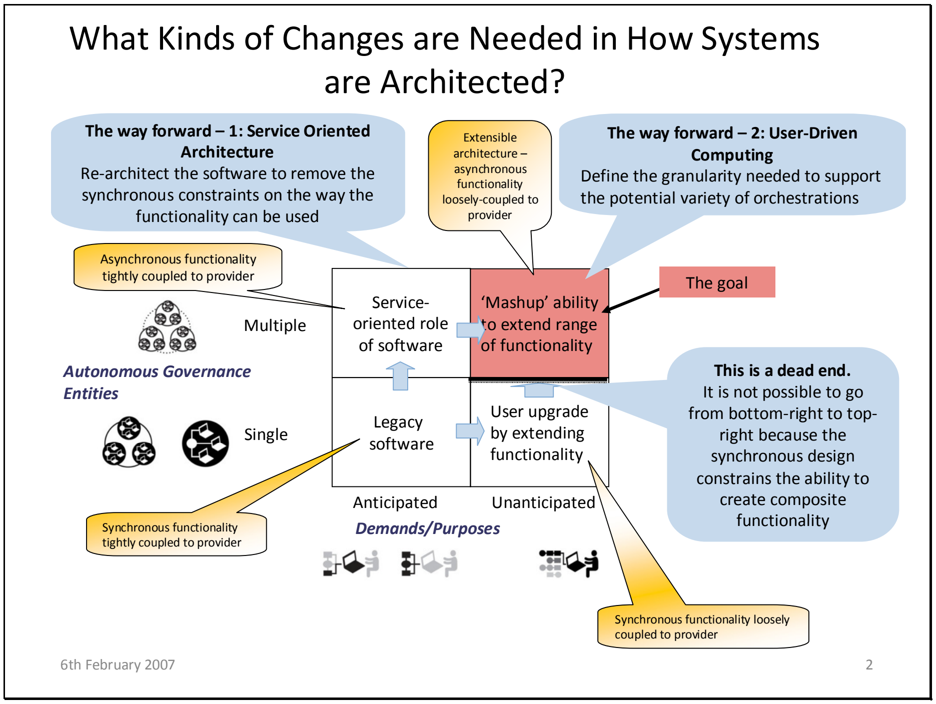
7 Investment Recommendations

As we have stated earlier in the report, our active research into investment criteria and investment recommendations was scheduled for the latter half of our work. As such, any investment recommendations we make here are not based on a methodical analysis of wildland fire economic data, nor can they be framed by a systemic look at the entire wildland fire environment. They are, quite simply, our "best educated guess", given our work to date. Our full set of interim findings and recommendations ad presented to members of the Governing Board in February 2008 are attached.

For this section of the report, we took the subset of recommendations that were directed at JFSP and put them in the context of the diagram below[39]. This is the near-term to mid-term goal of a Type I/Type II framework architecture. Then, considering the SOA and data fusion discussions of this report, we reviewed each JFSP recommendation and made appropriate annotations[40].

[39] This diagram is from an internal SEI working presentation; more information about its genesis can be found in the attached working presentation *Preliminary Middle-out Modeling Analysis*.

[40] The order of these recommendations has been slightly modified for this report


What Kinds of Changes are Needed in How Systems are Architected?
The way forward – 1: Service Oriented Architecture
Re-architect the software to remove the synchronous constraints on the way the functionality can be used
Extensible architecture – asynchronous functionality loosely-coupled to provider
The way forward – 2: User-Driven Computing
Define the granularity needed to support the potential variety of orchestrations
Asynchronous functionality tightly coupled to provider
The goal
Multiple
Service-oriented role of software
'Mashup' ability to extend range of functionality
Autonomous Governance Entities
This is a dead end.
It is not possible to go from bottom-right to top-right because the synchronous design constrains the ability to create composite functionality
Single
Legacy software
User upgrade by extending functionality
Anticipated
Unanticipated
Demands/Purposes
Synchronous functionality tightly coupled to provider
Synchronous functionality loosely coupled to provider
6th February 2007
2

PROTOTYPE ECOSYSTEM MANAGEMENT INVESTMENT APPROACH

> *Develop an initial investment analysis approach for justification of greater investment in ecosystem management practices to reduce suppression costs. This is a crucial step toward aligning practice to the preventive policy that the community espouses as superior. It would also help to justify further research funds as well as assist with prioritization of the science agenda.*

This approach must support a consistently applied, defendable, open set of policies and criteria. Despite great passion for ecosystem management issues within the community, resources and actions in the tool, system and data space favor support for suppression rather than that of land and ecosystem management. Additionally, the economic costs of **not** investing in ecosystem management are not being actively gathered and analyzed. Today's spending for suppression, land management, or rehabilitation is justified in terms of today's projected needs; it does not account for the longer term costs associated with ecosystems. As a result, incentives are missing for saving tomorrow's costs (reduced ecosystem management, suppression, or rehabilitation) by spending appropriately today.

This also highlights another key aspect of this effort – if an investment is not driven by real business needs, if it can not be economically justified, and it does not have the appropriate involvement and support of all the communities, it will fail.

EXPLICITLY DEFINE ROLES AND MANAGE RESPONSIBILITIES

> *JFSP must clearly define the scope of its responsibility for science and research, including any model and tool prototyping, validation, or evolution. While JFSP clearly has influence in defining roles and responsibilities within science and research, additional areas of role definition would enhance achievement of the overall wildland fire and fuels management missions. Some of these include investment planning, NWFEA, Service formation and publishing, data stewardship, and collaboration processes for using framework architectures.*
>
> *Included in these definitions should be the scope of responsibilities relative to other entities and jurisdictions. Part of this definition is any exit or completion criteria. Each entity must clearly define where its responsibilities begin and end with respect to any prototyping and productization of models, tools, systems, datasets, or framework architectures.*

The SOA/situational application/mashup discussion in this report does add a new dimension to this recommendation. Paraphrasing an article from IBM[41], there are three distinct roles (not job classifications or titles) related to situational applications and mashups:

- **Consumables builder**: This person is a line-of-business (LOB) or IT developer with traditional programming skills; they understand integration issues and use a range of programming tools. This person has access to enterprise data; they use tools and utilities to build consumables; and they use patterns to guide reusable asset creation. They work with the community to understand and anticipate their needs, and add the appropriate Services (both retroactively and proactively).
- **Situational application/mashup assembler**: This person is a power user who knows, or is close to, the business or operational need. They are capable of composing situational applications/mashups using browser-based tools. They can access a range of tools to fit their skills and domain expertise and they compose applications from consumables. They also provide guidance via programming-by-example, templates, utilities, and so on. They also share their applications and collaborate to improve them.
- **Situational application/mashup user**: This is the person who knows the business or operational need. They usually need quick answers and solutions, and they have access to standard desktop tools. They find and use situational applications/mashups quickly, rating and commenting on them as they do. They describe business needs for new situational applications/mashups SAs, and they need/demand real business benefits from them.

Tony Friko[42] (also from IBM) gives a similar definition, calling them "3 distinct layers":

- **Corporate IT**: controls and provisions data feeds; responsible for infrastructure, SLAs, etc.
- **Domain Expert**: decides which data feeds are required; compiles/assembles them into applications
- **End user**: consumes or uses the application(s)

This recommendation must account for and acknowledge these roles, which will be new to the community.

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[41] Mashups – The evolution of the SOA Part 2: Situational applications and the mashup ecosystem", http://www.ibm.com/developerworks/WebServices/library/ws‐soa‐mashups2/index.html, Stephen Watt, Nov 2007; NOTE – for the purposes of this report, we use the more general term SA where Watt used mashup

[42] Web 2.0 – *Mashups for the Knowledge Worker* Assemble – Wire – Share; IBM 2007

INITIATE COOPERATIVE RESEARCH APPROACHES

> *Due to both the significant gaps in current models, tools, and data sets to reflect the behaviors of actual situations and the rapidly changing nature of wildland fuel and fire management situations, JFSP sponsored research needs to adopt cooperative and collaborative inquiry approaches that are explicitly rooted in examining practices in the field. This includes continuous active feedback and participation with the user communities to validate individual and sets of models and tools as well as to evolve them (or replace, when necessary). For this problem domain, research that does not directly account for and incorporate the effects of an ecosystem is short sighted.*

Our discussion of data fusion in particular emphasizes the fact that many of our findings and recommendations dealt with concepts and issues that are outside the wildland fire community's traditional core competencies. The community can not afford to "go it alone" and should reach out to other organizations working in these areas.

CREATE CASE EXAMPLES OF FRAMEWORK ARCHITECTURES

> *Provide further funding and sponsorship for advanced software architectures to support multi-model, tool, and system integration. To meet the demands of the problem domain, these architectures must support ease of data fusion, including GIS data, and extensibility as new tools or systems are available. Evaluate the effectiveness of these platforms and incorporate lessons learned.*

The important point here is the last sentence. The wildland fire community can not adopt a Type III framework architecture as its first effort in this area – it must build to it. The experience gained in the implementation of the SOA design pattern and with situational applications and mashups must form the basis of the adoption of any Type III framework architecture.

EXPLICITLY EXPOSE FRAMEWORK FUNCTIONALITY

> *Expose and make available sufficient software information for any framework architecture to allow dynamic composability and extensibility to meet specific users' contexts. All systems, tools, or frameworks that JFSP funds (in part or wholly) should include the requirement to use an "open source software" concept. Here we apply the concept "open sourcing" as "open" within chosen communities who have agreed to peer rules on accessibility and feedback. (This is in contrast to the more general use of the term to mean available to the general public.) In this way, user groups and experts can provide some capability for critical review that will drive the science as well as the practices.*

The major implication here from the SOA discussion is the equally important need to determine which functionality – legacy or new – will not be exposed as a Service.

IDENTIFY CRITICAL INFORMATION NEEDED FOR DATA FUSION

> *Build on the data fusion analysis from this study to identify a minimal set of information required to fuse data from multiple sources (datasets, tools, models, etc.). For all systems, models, tools, or datasets that JFSP funds (in part or wholly) include the requirement to make this information readily visible. This would then allow other researchers, tool developers, or users to more easily determine what transformations of data would be required to fuse specific sets of data—and whether there is sufficient return on the investment.*

Even a Type I framework architecture will surface data inconsistency issues. As discussed in the data fusion section of this report, an approach based on defining the ontology of the data being fused in terms of its definition does not work; the semantics of the data fusion process must be formed by the way the data is to be used. Consideration should also be given to semantics defining the quality or utility of the data, again in the context of how it will be used.

INITIATE SHARED NORMS AND STANDARDS (JFSP OR NWFEA?)

> *Based on the culture within the wildland fire and fuels management community and the nature of your problem domain, we find that the most effective way to deal with the proliferating numbers of models, and tools is not through regulation or control, but through the formation of informal standards and norms that cover the relationship of "published" models and tools to the user community. "Published" models and tools will likely be of multiple forms, including (but not limited to) SOA-based Services. JFSP should take a leadership role to get things started. This should have active involvement of the user community, and framework architecture developers, and get leverage from the analysis under way through NWFEA.*

As stated in the attached conference presentation *Incorrect SOA Assumptions Can Lead to Mission Disaster*, "The good thing about standards is that there are so many to choose from." The emphasis on user involvement remains key, but some form of governance is required. Still quoting the presentation, most Web Services standards are emerging and subject to multiple interpretations. This plays heavily into the area of data compatibility and data fusion as (again quoting the presentation) interoperability needs agreement on both syntax and semantics. Web Services enable syntactic interoperability:

- XML Schema defines structure and data types
- WSDL defines the interfaces: operations, parameters and return values

- Available information, technologies and tool support

Web Services do not guarantee semantic interoperability:

- •XML and WSDL do not define the meaning of data
- •WSDL does not define what a service does

In addition within the fire science community, the community also has the need for a more basic set of norms, such as creating processes for letting stakeholders know what models are available, what they do and don't do, how capabilities can be used, etc.

REFOCUS SCIENCE AND RESEARCH AREAS

Based on our current analysis, JFSP needs to significantly refocus and enhance its science and research agenda and investments in five key areas:

- *data fusion (e.g. data fusion strategies, meta-data models)*
- *complex ecosystem management (e.g., fire and smoke behavior in the context of complete ecosystem behavior)*
- *framework architectures (refer to theme discussion on distributed collaboration)*
- *ecosystem management decision support (including socio-economic analysis)*
- *social issues as related to ecosystem management and suppression response (i.e., WUI and other demographics included)*

These do not need any further clarification in light of the SOA and data fusion discussions.

INSTITUTE PROACTIVE OPERATIONAL AND TECHNOLOGY SCANNING

While our analysis indicates a number of key areas (noted above) that require immediate focus and investment, JFSP also needs to institute an effective (and analytical) approach to continuously understanding the changing operational situations that must be accommodated and emerging technologies that might be leveraged. (An activity aligned with this principle seems to have lead to the present study and other efforts and can be enlarged.) The envisioned approach includes active involvement (and possible participation) in research occurring in other countries (e.g., Canada, EU – Fire Paradox, Australia) and with other U.S. agencies (e.g. NASA, NOAA). Benchmarking is possible with practitioners in other busi-

nesses who excel at this kind of scanning. The results of this scanning need to be regularly folded into the science and research agenda and investment decisions.

This is especially true regarding emerging SOA-focused technologies and standards.

A LAST RECOMMENDATION – START TODAY

The last recommendation we can make, though, is the simplest one – start today. The changes needed in the wildland fire community are significant. However, the community has demonstrated its ability to effect these scale changes in the past. Additionally, the members of the wildland fire community are dedicated and capable, and are committed to their mission.

JFSP is a unique organization, and is uniquely placed in the wildland fire community. We believe, however, that the move to a Type I/Type II/Type III environment will completely change the way JFSP operates, and this change must start today as well. This is not to say that we believe that the Governing Board can implement any of our recommendations in the FY 2008 investment decision cycle. However, the Governing Board can begin to change its *mindset* today by considering how it will function in the future.

As a simple example, regarding the discussion describing the new roles in a SOA environment – who will JFSP support with its investment funds? The consumables builder, the mashup assembler, or the mashup user? While this not only needs considerable dialogue with NWFEA and other enterprise EA and IT organizations, it also needs considerable dialogue with users and developers. Whichever JFSP chooses to emphasize, however, will have a profound impact on how JFSP perceives it self, how it is perceived, how it invests, and how it measures success.

As another example, JFSP's investment process in FY09 and beyond will likely funds new Services or the conversion of existing capabilities into Services. To do this, JFSP must determine the type and level of expertise it will need to understand the issues and devisions they will face. Pushing on this further, let's assume that NWFEA or the EA community assumes responsibility for Service run-time governance (the behavior of Services while they are in the production environment). Will JFSP – as the "voice of the user" and through the criteria it places in its investment process – assume responsibility for Service design-time governance (creating, exposing, and using Services)? This is not as far-fetched as it may seem on the surface – the argument can be made that this type of governance should be close to the builder, and JFSP is a candidate body.

Regardless of how these particular issues resolve them selves, the point still remains that there will be a considerable shift in JFSP's investment focus. And while these are neither investment criteria nor recommendations, we think that JFSP should also consider these issues:

- Include data semantics issues, even at the most basic level, on each new investment decision – not just for the sake of the semantics, but also to help change the culture to a mindset that semantics are a critical issue.
- Invest in small SOA efforts – not just for the advantages it can provide to the users, but to build the cadre of developers, architects and users who will form the core of the subsequent efforts. For example, we believe that the current BlueSky effort could be the nucleus of a potential wildland fire SOA "center of excellence".
- Invest in mission decomposition studies, breaking an operational process down into "building blocks" until they can not be broken down further, to support the determination of needed Services.
- At the same time, invest in a bottom-up approach to examine existing functionality to determine what could be exposed as a Service, and at what level of granularity.
- Examine the utility/viability of current policies regarding data and applications in light of the move to Web-based Services and the goal of providing "power to the edge" – which policies help, which ones hinder, and how can the policies that hinder be changed?

8 Summary Thoughts

It is not unusual for our customers to observe that our recommendations do not address software in the manner they initially expected (though that expectation is almost universally unstated). This is because the issues facing our customers are almost never pure software engineering issues. We are aware of the irony that only an organization steeped in software engineering and acquisition can tell another organization that their biggest problems are not in the software, but there it is.

We do not mean to imply that there will not be software-related challenges as the community moves towards the net-centric world we recommend. However, the large science, governance, and culture issues will dominate these. Put another way, software issues can be addressed if the science, governance, and culture support them, but software – no mater how good – can not overcome the obstacles of inadequate science, governance, and culture.